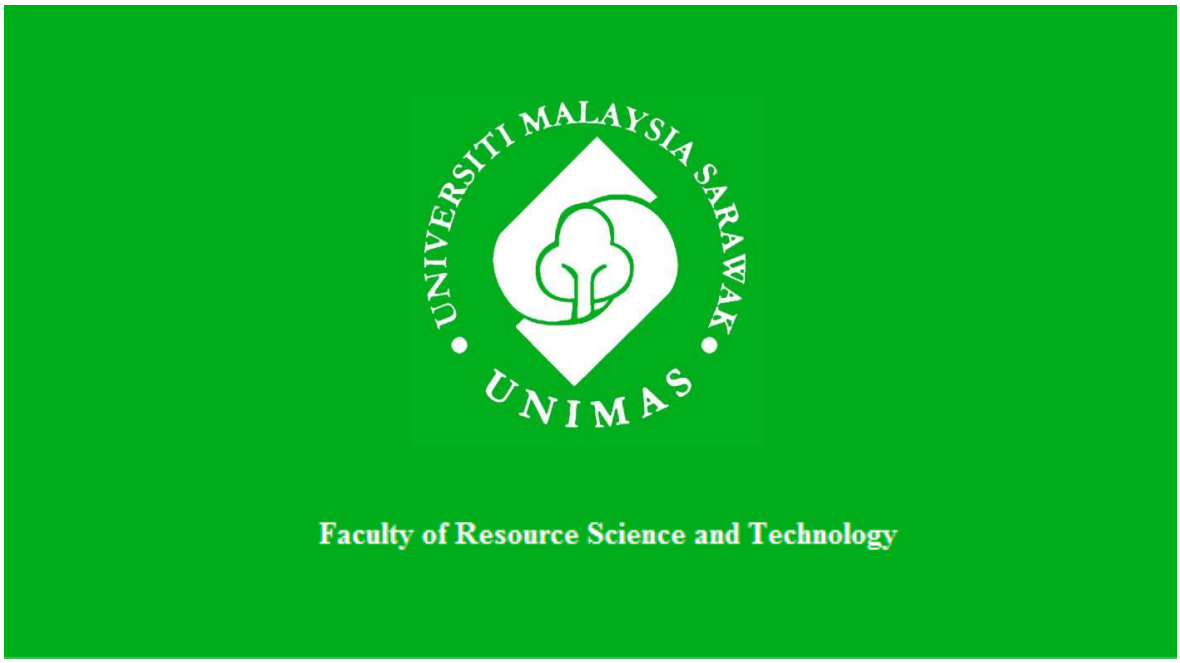

FIELD TRIAL ON THE GROWTH PERFORMANCE AND YIELD OF VEGETABLE CROPS AFTER APPLICATION OF ORGANIC SOIL AMENDMENTS

TANG ING QING

Bachelor of Science with Honours
(Plant Resource Science and Management)
2017

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

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Final Year Project Report	✓
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FIELD TRIAL ON THE GROWTH PERFORMANCE AND YIELD OF VEGETABLE CROPS AFTER APPLICATION OF ORGANIC SOIL AMENDMENTS

TANG ING QING

This thesis is submitted in partial fulfillment of the requirement for the degree of the Bachelor of Science with Honours

(Plant Resource Science and Management)

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2017

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DECLARATION

I hereby declare that this Final Year Project report 2017 is based on my original work except for the quotations and citations which has fully acknowledged and declare that it has not been or concurrently submitted for any other degree at UNIMAS or other institutions of higher learning.

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Field trial on the growth performance and yield of vegetable crops after application of organic soil amendments

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ABSTRACT

Assessment of the potential performance of organic soil amendments was conducted through field planting of Long Bean (*Vigna unguiculata* subsp. *sesquipedalis*), Okra (*Abelmoschus esculentus*) and Pak Choy (*Brassica rapa* subsp. *chinensis*) at farmland located in Kruin area, Sabal, Sarawak. In this study, 2 types of organic soil amendments were used, namely untreated and treated Oil Palm Empty Fruit Bunch (OPEFB) compost, which were without bacterial inoculation and with bacterial inoculation respectively. Treated OPEFB compost was inoculated with various bacteria strains namely *Burkholderia unamae*, *Enterobacter cloacae* and *Bacillus amyloliquefaciens*. For this field trial test, 11 treatments for each type of the planted vegetables consisting both untreated and treated OPEFB compost were applied with the combination of chemical fertilizer at the rate of 0%, 25%, 50%, 75% and 100%. One planting cycle of Long Bean and Okra were 3 months for Long Bean and Okra whereas Pak Choy was cultivated for 1 month. For the evaluation of growth performance and yield assessment, growth parameter such as plant height, stem diameter, number of leaf and leaf area were recorded at an interval of every two weeks. Yield collected were weighed and recorded for all vegetable crops. Meanwhile, the vegetable crops were harvested for biomass determination at the end of the experiment. From this study, the growth and yield of selected vegetable crops cultivated with untreated and treated organic compost were revealed. In general, both untreated and treated OPEFB compost promoted yield production of Long Bean. Treated OPEFB compost promoted yield production of Pak Choy. OPEFB compost did not showed positive effect on the yield production of Okra in this experiment.

Keywords: Oil palm empty fruit bunch (OPEFB), organic soil amendments, growth performance, yield, vegetable crops.

ABSTRAK

Penilaian prestasi potensi baja organik telah dijalankan melalui penanaman kacang panjang (*Vigna unguiculata* subsp. *sesquipedalis*), bendi (*Abelmoschus esculentus*) dan pak choy (*Brassica Rapa* subsp. *chinensis*) di tanah ladang, Kampung Kruin, Sabal, Sarawak. Dalam kajian ini, dua jenis baja organik telah digunakan, iaitu kompos daripada tandan buah kelapa sawit (OPEFB) yang tidak dirawat dan dirawat, iaitu tanpa inokulasi bakteria dan berinokulasi bakteria. Kompos OPEFB yang dirawat telah disuntik dengan pelbagai jenis bakteria iaitu *Burkholderia unamae*, *Enterobacter cloacae* dan *Bacillus amyloliquefaciens*. Dalam ujian percubaan lapangan ini, setiap tanaman ditanam di bawah 11 rawatan yang terdiri daripada kedua-dua kompos OPEFB yang tidak dirawat dan dirawat dengan gabungan baja kimia pada kadar 0%, 25%, 50%, 75% dan 100%. Satu kitaran penanaman untuk kacang panjang dan bendi adalah 3 bulan manakala pak choy telah ditanam selama 1 bulan. Untuk penilaian prestasi pertumbuhan dan penilaian hasil, parameter pertumbuhan seperti ketinggian tumbuhan, garis pusat batang, bilangan daun, dan keluasan daun telah diukur pada selang setiap dua minggu. Hasil yang diperolehi telah ditimbang dan direkodkan untuk semua jenis tanaman sayur-sayuran. Tanaman sayur-sayuran akan dituai untuk biomas penentuan pada akhir eksperimen. Dari kajian ini, pertumbuhan dan hasil tanaman sayur-sayuran yang dipilih ditanam dengan baja organik yang tidak dirawat dan dirawat telah dinilai. Secara umum, keuda-dua kompos OPEFB yang tidak dirawat dan dirawat menggalakkan hasil pengeluaran yang baik bagi kacang panjang. Kompos OPEFB yang dirawat menggalakkan hasil pengeluaran yang baik bagi pak choy. Kompos OPEFB tidak menunjukkan kesan positif pada hasil pengeluaran bagi bendi dalam eksperimen ini.

Kata kunci: tandan buah kelapa sawit (OPEFB), baja organik, prestasi pertumbuhan, hasil, tanaman sayur-sayuran.

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LIST OF ABBREVIATIONS

Av. P	Available Phosphorus
C	Carbon
CEC	Cation Exchange Capacity
EC	Electrical Conductivity
FFB	Fresh Fruit Bunch
GAP	Good Agricultural Practice
N	Nitrogen
NH^{4+}	Ammonium
NO_3^-	Nitrate
NPK	Nitrogen: Phosphorus: Potassium
P	Phosphorus
OPEFB	Oil Palm Empty Fruit Bunch
RHA	Rice Husk Ash
SOM	Soil Organic Matters
T	Treatment
T-C	Total Carbon
T-N	Total Nitrogen

1.0 INTRODUCTION

1.1 Background of study

By 2050 the world's population will increase to more than 9 billion people, in which the population is 34% higher as compared to the population in 2000s decades (FAO, 2009). In order to fulfill the food demands of current population, food production must be increased by 70%. As of food security is the main concern in the future, technology development of agricultural biomass into organic compost is aimed for a higher yield production at the same time minimize environmental problem (JIRCAS, 2016).

However, modernization of agriculture system relies more on agrochemicals since 1950's. Despite chemical fertilizer application benefits in crops production capacity, extensive inorganic fertilizer inputs contribute significantly to soil degradation, and consequently affects biodiversity of soil beneficial microorganisms, soil structure, soil compaction, mineralization of soil organic matter (SOM), soil organic carbon, nutrients available for plants and hence direct impact on yield production (Baishya, 2015).

By reducing the usage of chemical fertilizer with the replacement of organic amendments, soil quality including soil structure for better root penetration, water infiltration of soil, nutrient supply for plant uptake, soil fertility as well as population of soil microorganism can be enhanced (Leslie, 2002; Dawe *et al.*, 2003; Jilani *et al.*, 2007; Craig and Gwen, 2013; Gandahi and Hanafi, 2014). Besides, soil cation exchange capacity (CEC) is improved as the plant nutrients are easily released into soil solution which to be uptake by plants. Thus, application of organic compost not only promote plant growth and crop productivity, it alleviates ecological and environmental risk in long run.

As of growth rate of agro-food production in Malaysia is lower than that of neighboring countries, integrated nutrient management by combining organic compost with the

chemical fertilizer for sustainable land use and to enhance yield productivity growth is encouraged (Chen, 2006; ETP, 2012). As the nutrient contents supply by the organic amendments are usually low, thus large amount of organic amendments are usually required to achieve optimal growth of plants. Mixing of chemical fertilizers with organic is the only alternative way to achieve this goal. Combination of organic amendments and chemical fertilizers could be the one of the options in improving the growth performance and yield of vegetable crops (Jilani *et al.*, 2007). Therefore, Malaysian government is emphasizing on sustainable agriculture by applying organic amendments to replace the amount of chemical fertilizer used (Neda *et al*., 2014; Masunga *et al.*, 2016).

Poultry manure, oil palm empty fruit bunch (OPEFB) compost, biosolids, green manure and waste by-products from manufacturing processes are used as organic waste materials to produce organic amendments (Kala *et al*., 2009; Goss *et al*., 2013; Kavitha *et al*., 2013; Siti *et al*., 2015). In Malaysia, OPEFB compost are mainly recycled into organic amendments as it is one of the by product from oil palm industry in Malaysia. According to Bari *et al*. (2010), approximately 9% of oil palm biomass left over from 5.0 million ha of oil palm plantation annually after palm oil is extracted from Fresh Fruit Bunch and it is about 4kg of dry biomass are accumulated from each kg of palm oil production. From these 4kg of dry biomass, there are roughly one third dry biomass derived from fresh fruit bunch (FFB) and another two third represented by the trunk and frond materials (Fauziah *et al*., 2010; Ispal, 2012). The production of organic amendments by using renewable waste from oil palm industries is an efficient agro-waste management strategy at the same time reduces the negative impacts of chemical fertilizer to the environment.

Since OPEFB compost comprised of lignocellulosic material, microorganism is required to promote the decomposition of these materials into plant available form nutrients (Jilani *et al.*, 2007). Effective microbes such as *Burkholderia unamae, Enterobacter cloacae* and

Bacillus amyloliquefaciens are used as activator for the composting process of OPEFB into organic compost in a rapid manner (Muhamad, 2016). Humus-like product that decomposed by bacteria stimulates plant growth as it is more stable in providing nutrients to the plant (Alexandra and Jose, 2005).

In a nutshell, soil degradation is irreversible, especially through agricultural production systems. Degradation of soil caused by agrochemical practices is difficult to be recovered (Baishya, 2015). Thus, by replacing portion of the chemical fertilizer usage with the application of organic soil amendments in green farming practices hold a great promise for the aspect of agricultural crop production for a long-term perspective (FAO, 2009). Therefore, it is one of the good options to utilize organic amendments with the combinations of chemical fertilizer towards Good Agricultural Practice (GAP) in achieving the goal of sustainable agriculture in conserving soil productivity and fertility for future use (Jilani *et al.*, 2007; FAO, 2008; Shobri *et al*., 2016).

1.2 Problem Statements

Many researchers conducted studies regarding organic soil amendments from various organic waste materials such as poultry manure, OPEFB, biosolids, green manure and waste by-products from manufacturing processes (Kala *et al.*, 2009; Goss *et al.*, 2013; Kavitha *et al.*, 2013; Siti *et al.*, 2015). With the large expansion of oil palm industries in Malaysia, various studies have been conducted on OPEFB, which is the by-product from the extraction of crude palm oil. Combination of OPEFB with sewage sludge and chicken manure were used as potting media for ornamentals plants and vegetables (Kala *et al.*, 2009; Yasmeen *et al.*, 2009). Fruit vegetables, *Abelmoschus esculentus* showed positive effect in terms of growth and yield performance when applied with OPEFB compost

inoculated with 20% of *Bacillus sp.* (Sarowani, 2014). Inoculation of OPEFB with the mixture of bacterial strains showed positive result in term of nutrient status of the OPEFB compost (Kavitha *et al*., 2013). As mentioned above, many studies have been conducted on OPEFB compost with different microbial inoculants, but most study stated were under control environment within greenhouse trials. Thus, there is a need to conduct similar experiment under actual field planting as the microenvironment at field condition might give rise to different outcomes especially on the growth performance and yield of vegetable crops (Silva *et al.*, 2010; Muhammad, 2016).

1.3 Objectives

With regards to the problem statement above, the objectives of this study are as follow:

1. To evaluate the growth performance and yield of selected vegetable crops, namely Long Bean (*Vigna unguiculata* subsp. *sesquipedalis*), Okra (*Abelmoschus esculentus*) and Pak Choy (*Brassica rapa* subsp. *chinensis*) after application of organic soil amendments under field trial test.
2. To determine the effectiveness of untreated and treated compost for the growth performance and yield production of selected vegetable crops.

2.0 LITERATURE REVIEW

2.1 Organic Soil Amendments

Organic soil amendments are materials that mixed into the soil to enhance soil physicochemical properties as well as to aid the plant growth (University of California, 2010). Organic soil amendments provide food for the microbes to decompose the organic matter into mineral nutrients in plant available form. Such materials are said sustainable in terms of managing crops production (Abiven *et al*., 2009; Scotti *et al*., 2015).

To reduce the dependency of chemical fertilizers in agriculture practices, one of the alternative ways to add organic amendments with the combination of chemical fertilizers in the current farming practices (Jilani *et al.*, 2007). As organic amendments usually have lower nutrient content, thus, an adequate amount of chemical fertilizers is required to fulfill the nutrient supply to the vegetables for maximum crop production.

The application of organic amendments may not necessary lead to higher productivity of crop yield in short period of time but its returns are of a long-term nature (Thippeswamy, 2013). This is due to the fact that application of organic amendments supplies soil organic matter with continuous microbial activities. Hence, soil structure is stabilized and soil permeability is improved in term of soil physical properties (Bouajila *et al*., 2011).

Besides, activities of soil microorganism help in improving soil aggregate stability, water holding capacity, soil porosity and soil quality in consequence manner. Soil bulk density will decrease due to increased soil aggregate stability (Peltre *et al*., 2015). Hence, the soil particles are arranged in porous aggregates in which the pore spaces are filled with variable mix of water and air. Such condition indicated that organic soil amendments indirectly improve soil physical properties. Thus, soil fertility is improved which promotes plant growth and productive capacity (Abiven *et al.*, 2009). Additionally, organic amendments

also improve chemical characteristics of soils by increasing total nitrogen and organic matter in the soil. Besides, soil organic Carbon (C) stock for intensive agricultural cultivation site can be recovered to optimum level (Scotti *et al*., 2015). High organic carbon content in the soil also functions in diminishing climatic heating.

Several types of organic amendments that are commonly used are vermicompost tea, poultry manure, biosolids, sewage sludge, rice husk ash (RHA) and OPEFB compost (Kala *et al*., 2009; Anita *et al*., 2011; Pant *et al*., 2011; Scotti *et al*., 2015). In Malaysia, OPEFB composts are commonly used to produce organic amendments in Malaysia as it is significantly produced from the oil palm industries. As the oil palm production increased, there are large amount of renewable biomass, especially OPEFB are left behind (Tanaka *et al*., 2004). The accumulated 90 million tons of OPEFB may lead to pollution and environmental hazards without appropriate management (Singh *et al*., 2011; Embrandiri *et al*., 2012). Therefore, by adapting OPEFB as organic soil amendments in agriculture practices, the accumulated OPEFB from oil palm industries can be greatly reduced (Thippeswamy, 2013; Gandahi and Hanafi, 2016). Moreover, the cost of purchasing chemical fertilizer for cultivation also minimized.

2.2 Microbial inoculation in the production of organic soil amendments to promote plant growth and yield production

Organic waste materials undergo composting process and transform into organic soil amendments with the aid of microorganisms (Bashan, 1998; Sangakkara, 2002). For the composting process, aerobic method is used as higher temperature is attained for a more rapid manner to obtain mature compost which is available for plant uptake (Kala *et al*., 2009). Since EFB compost has been identified as the carrier for biofertilizer formulation, plant growth promoting rhizobacteria (PGPR) or plant growth promoting bacteria (PGPB)

are added to fasten the composting process by degrading compost material into mature compost and used as organic soil amendments to stimulate plant growth and yield production (Bashan, 1998; Yasmin *et al*., 2007; Kavitha *et al*., 2013; Pupatty and Radziah, 2013). Besides, PGPR flourish the rhizosphere of plants, by growing in, on, or around plant tissues and, thus facilitate plant nutrients uptake.

Several genera such as *Bacillus*, *Burkholderia*, *Enterobacter*, *Pseudomonas* and *Rhizobium* are classified as PGPR or PGPB (Sharma *et al*., 2013). In this study, antagonistic bacteria namely *Bacillus amyloliquefaciens*, *Burkholderia unamae* and *Enterobacter cloacae* which are used to depolymerize the component of OPEFB such as lignin, cellulose and hemicellulose as continued from greenhouse test (Muhamad, 2016). Inoculation of *Bacillus amyloliquefaciens* to the soils exert beneficial effect on soil rhizosphere properties (enzyme activities, Indole-3-acetic acid (IAA) production, microbial respiration, microbial biomass-C) and thus improved root development as well as plant growth above ground, yield and nutrition content in straw and seeds of soybean (*Glycine max* L. Merrill) (Sharma *et al*., 2013). Meanwhile, both *Bacillus* spp. and *Burkholderia* spp. contribute to plant growth promotion by fixing atmospheric nitrogen (N_2) into plant available form and increasing phytase activity to solubilize sufficient available phosphorus for plant nutrients uptake (Tao *et al*., 2008; Ramirez and Kloepper, 2010; Calvo *et al*., 2014). *Burkholderia* spp. is also reported as an effective plant growth promoter which can utilize citrate as carbon source for a better root colonization and, thus better plant growth (Weisskopf *et al*., 2011). *Burkholderia unamae* adapt well at the soil pH of 4.5 to 7.1 and colonize the rhizosphere to mineralize organic matter into plant available form for plant growth promotion (Caballero-Mellado *et al*., 2004). *Enterobacter* spp. are facultative anaerobes which can adapt in diverse environments. *Enterobacter cloacae* has been identified to

enhance root system of rice and, thus increased nutrients and chlorophyll content in the leaves as well as the production of tiller (Suprapta *et al*., 2014).

2.3 Agronomic information on selected vegetable crops

2.3.1 Long Bean (*Vigna unguiculata* subsp. *sesquipedalis*)

Long Bean (*Vigna unguiculata* subsp. *sesquipedalis*) belongs to family Fabaceae (Herklots, 1972). It has trifoliate leaves, purplish flowers and the fruits are present as long narrow pods in pairs (Figure 1). Long Bean is a perennial herbaceous climbing vine which is normally grown in the tropics. It is an important legumes plant in Asia and it has high economic potential which contributed to sufficient domestic supply.

Application of vermicompost showed significant positive effect on the plant growth and plant productivity as well as shoot length, root length, basal area, biomass accumulation of Long Bean (Roy, 2010). Besides that, application of poultry manure showed positive result in overall of the growth (number of leaves, chlorophyll content and plant height) and yield parameters (number of pod, length and weight of pod, biomass and leaf moisture content) of Long Bean.

In Malaysia, cultivation of Long Bean is conducted following the standard agronomic practices from (DOA, 2016). For the land preparation, the soil is ploughed to improve root growth. Planting bed with the size of 7.5m length, 1.2m wide and 0.25m height is recommended. The recommended amount of organic soil amendments to be applied for 1ha land area is 5tan. For the planting distance between each of the Long Bean plant is 0.6m (DOA Sarawak, 2016).

Two (2) seeds are sowed for each hole. After the seeds sprout and grow, one of the Long Bean plant is repealed and leave only one plant per hole. Three weeks after planting, the

Long Bean plants are supported with 2m height stake. Nylon ropes are tied and connected as netting each other for the Long Bean plant to coil up the nylon ropes.

One planting cycle for Long Bean takes 3 months of time. Watering of Long Bean is conducted twice a day in the morning and evening. Seven hundred kilogram (700 kg) of chemical fertilizer NPK Blue Special (12:12:17:2) is recommended for 1 ha of the land area. Application of fertilizer is conducted at 2, 4, 6, 8, 10 week after planting of Long Bean.

After sowing, Long Bean reaches maturity in 90 days. Long Bean can be harvested approximately at the 6th weeks after planting. The crops are collected every 2 days for 6 weeks (DOA, 2016). The recommended yield of 1ha Long Bean cultivation is estimated at 10,000kg to 17,500kg.

In term of fruit quality, the length of Long Bean pods is categorized into 3 categories (FAMA, 2006). Long Bean pod with less than 35 cm is defined as short, 35 cm to 50 cm as medium and more than 50cm as long. Besides, maturity of the long bean pods is classified into 3 classes which are immature (light green pods attached with flowers), mature (green pods) and over mature (yellowish green pods with bulging seeds).

Figure 1: *Vigna unguiculata* subsp. *sesquipedalis* (Long Bean).

2.3.2 Okra (*Abelmoshus esculentus*)

Okra *(Abelmoschus esculentus*) is a member of the Malvacea family (Fonseka *et al.*, 2010). Okra is an annual herb which is widely cultivated vegetable crop in tropical and subtropical region. Okra has hairy broad leaves, yellow with dark red or mauve at the center of the petals and the Okra fruit present as a capsule as shown in Figure 2 (Oppong *et al*., 2011).

Okra showed positive response in term of yield production of Okra inoculated with *Azospirillum* + 75% recommended nitrogen and full dose of phosphorus and potassium as compared to control treatment with recommended dose of NPK with the ratio 120:60:60 kg ha^{-1} (Anant and Manohar, 2001). Besides, *Azobacter* + Cowdung 5 tan ha^{-1}, *Azospirillum* + Cowdung 5 tan ha^{-1} and *Azobacter* + *Azospirillum* + Cowdung 5 tan ha^{-1} were proven that promote growth of Okra in terms of number of leaves, stem base diameter, root length, root dry weight, leaf area index and crop growth rate (Ashrafuzzaman *et al*., 2003). In addition, Okra showed positive effect in terms of growth and yield performance when applied with OPEFB compost inoculated with 20% of *Bacillus sp.* (Sarowani, 2014).

or land preparation, the soil is ploughed at 15-22cm deep to improve root growth. Planting bed with the size of 20.0m length, 1.2m wide and 0.25m height is recommended. The recommended amount of organic soil amendments to be applied for 1ha of area is 5tan. For the planting distance between each of the Okra plant is 0.9m (DOA Sarawak, 2016). Organic soil amendments are needed to mix up with the soils 2 weeks before planting.

Two (2) seeds are sowed for each hole at 2.5cm deep on the planting beds. After the seeds sprout and grow, one of the Okra plant is repealed and leave only one healthy seedling per planting hole.